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Concreteness Effect in the reading processing of Chinese Disyllabic Words by School-aged children in Hong Kong

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Abstract

This study investigated the concreteness effect and the developmental trend of reading process of Chinese disyllabic words by normal primary school-aged children in Hong Kong. According to the Dual Coding Theory (Paivio 1986), it was hypothesised that students would read concrete words more accurately than abstract words. However, previous studies failed to agree on the concreteness effect in Chinese word processing, which might be due to the lack of control on component character frequency. In order to find out concreteness effect in primary school-aged population, the present study manipulated component character frequency, whole word frequency and concreteness effect across grades. Students from Primary two (P2), Primary three (P3) and Primary five (P5) with normal intelligence and reading skills were asked to read aloud 160 words. Results confirmed concreteness effect existed in both high and low frequency words but the effect was stronger when the word frequency and the component character frequency were low. The concreteness effect in reading processing emerged as early as P2 but diminished in P3 and P5.

INTRODUCTION

There were many studies investigating concreteness effect on alphabetic language. These studies have successfully proved that people memorised and identified concrete words with higher accuracy than abstract words through psycholinguistic experiments such as lexical decision, naming, word recognition, sentence comprehension and recall (Kounios & Holcomb 1994; Coltheart, Laxon & Keating 1988; Jessen, Heun, Erb, Granath, Klose, Papassotiropoulos, & Grodd 2000)

Dual-Coding theory

The Dual-coding theory by Paivio (1986) argued that there were two separate processing systems in human cognition: the verbal and nonverbal system. He hypothesized that the verbal system might be located in left hemisphere while the imagery system might be located in the right hemisphere. The verbal system was responsible for the processing of linguistic input while the nonverbal system was responsible for the processing of nonverbal objects and events. The former was language based while the latter was imagery based. The two systems were functionally and structurally distinct (Paivio 1986). Yet, they could be activated either alone or simultaneously. Based on these theories, Paivio (1986) hypothesized that concrete words could be processed by both system while abstract words could be processed by the verbal system only because concrete words consisted representational units in verbal and imagery systems which improved the processing of concrete words. Neuroanatomically, Paivio (1986) claimed that concrete words might be encoded in the right hemisphere whereas abstract words might be encoded in the left hemisphere. Paivio (1986) also predicted that the processing of abstract and concrete words would not be affected by word frequency.

In an event-related brain potentials (ERP) study, Kounios & Holcomb (1994) investigated the topographic distribution of ERP in lexical decision and concrete-abstract classification tasks using English words. The results showed that ERP data of concrete words was larger over right hemisphere while ERPs data of abstract words was larger in left hemisphere. This confirmed the Dual-Coding Theory that left hemisphere mainly responsible for processing abstract words while right hemisphere primarily responsible for concrete words.

Jessen et al. (2000) explained the term “concreteness effect” as the processing of concrete nouns such as “desk (書桌)” would be faster and more accurate than abstract nouns such as “meditation (冥想)” in many psycholinguistic experiments. Their study aimed at identifying the cortical regions that are responsible for encoding German concrete and abstract nouns by functional magnetic resonance imaging (fMRI). Results showed that encoding of concrete words triggered stronger activation in the primary language processing area—left hemisphere and an additional imagery based region—right parietal lobe. This finding supported the dual-coding theory that processing of concrete words involved a verbal system in left hemisphere and an imagery system in right hemisphere.

Although many studies investigated concreteness effect by means of various psycholinguist experiments, they were largely conducted in foreign adult population, which made use of alphabetic language, for example, English and German. Previous research proved concreteness effect in the processing of alphabetic language; yet, whether concreteness effect exists in Chinese language is still unknown. It is because there are great differences between English and Chinese words processing. English is an alphabetic language. Each English word is formed by a string of letters to become a morpheme. When reading English, we gain access to its pronunciation from the letters

but fail to access its semantic meaning through these letters. Contradictory to English, Chinese is a logographic language. Each Chinese word can be formed by more than one character. Each character represents a single morpheme. We can have a direct access to the semantic meaning through the semantic radical that gives information to the meaning of the character. A direct access to semantic representation in Chinese is a great difference from the processing of English alphabetic language. It can be hypothesised that the role of concreteness effect in Chinese word processing might be different from that in English. Therefore, it is important to study concreteness effect in Chinese logographic language.

Apart from the property of semantic representation in Chinese word processing, another consideration was the effect of component character in Chinese. According to Zhou, Shu, Bi & Shi (1999), disyllabic words occupied 73.6% of all the words in Chinese language. Among the disyllabic words, there were around one-third of them are modifier compound. Modifier compound meant that the second character of a Chinese disyllabic word carried the semantic meaning of the whole word, thus, the second character was interpreted as more important that the first character. For example, “老鼠” is a modifier compound which meant “mouse” consisted of the first character “老” which meant “old” and the second character “鼠” which meant mouse; from this word, the second character directly gave us more information on the meaning of the whole word than the first character. Therefore, it was hypothesized that the second character that carried more semantic information would be affected by concreteness effect to a larger extent. Apart from the character position, it was hypothesized that concreteness effect might mainly exist in low frequency component character since the activation may be too weak to access the pronunciation; hence, students chose to rely on the semantic information of the

character for processing. Therefore, it was hypothesized that concreteness effect might mainly existed in the second character especially low frequency component character.

Another reason to study concreteness effect in Chinese disyllabic words was the ambiguity of the meaning in single character. As mentioned in the previous paragraph, 73.6% of the Chinese words were disyllabic words. Each character was a single morpheme that can combine with another character to form a new vocabulary. Therefore, the meaning of a single character could be totally different from the meaning of the whole disyllabic word. For example, “校服” which specifically means “school uniform”; yet, there are many meanings when we read the two characters independently. The first character “校” can be interpreted as “school” or “modeling” while the second character “服” can be interpreted as “clothes” or “obey”. The meaning of a single character is too ambiguous in Chinese language. In order to find out the role of concreteness effect in the processing of Chinese words, it is important to study Chinese disyllabic words.

However, very few studies were done on concreteness effect in the processing of Chinese words. In Chinese population, only Zhang & Zhang (1997) and Chen & Peng (1998) studied concreteness effect in the process of Chinese disyllabic words in adult population. Yet, their results were contradictory.

In Zhang and Zhang (1997)’s study, they investigated concreteness effect in the processing of Chinese disyllabic words by lexical decision task in Chinese adult population. Twenty subjects from Beijing University were asked to perform lexical decision task on 240 words. They only controlled for the whole word frequency by selecting the high and low frequency words from the “*Modern Chinese Frequency Dictionary*” (1986). Ten postgraduate students were asked to rate the concreteness level of the stimuli according to a seven-point rating scale, in which, point seven is the most concrete while point one is most abstract. Result showed that equivalent lexical decision

times were found in both concrete and abstract words in high frequency words whereas lexical decision time was faster for concrete words than abstract words in low frequency words. The finding indicated that concreteness effect only existed in low frequency words. Statistically significant interaction effect between concreteness and frequency was observed. They argued the results by proposing that the representation and contextual information in concrete low frequency words were easier to retrieve than abstract rare words. Also, they reasoned that the contextual support and representation of frequent words was so easily accessible that concreteness effect did not exist. In his experiment, the fact that concreteness effect was found only in low frequency word was not consistent with the prediction of the Dual Coding Theory.

Contradictory to Zhang & Zhang (1997) study, Chen & Peng (1998)'s study found that concreteness effect only existed in high frequency Chinese disyllabic words. Similar to Zhang & Zhang (1997), Chen & Peng (1998) also controlled the whole word frequency and the source of the words was the same. However, they did not manipulate the component character frequency. Twenty students were asked to rate the level of concreteness according to a seven-point rating scale, in which, point seven is the most concrete while point one is most abstract. Twenty-nine subjects were asked to perform the lexical decision task on 180 words while another 20 subjects participated in the naming latency task. Results showed that naming and lexical decision was faster for concrete words than abstract words in high frequency words only. Chen & Peng (1998)'s argued that since high frequency and concrete words consisted of more contextual support and representation and therefore more representational units, the processing was faster than abstract and low frequency words. Therefore, lexical information was extracted faster from high frequency concrete words. They also hypothesized that activation of the graphic representation could activate the phonological and the semantic

representations; hence, activation of phonological representation of concrete words was faster than abstract words with the help from early activation from semantic representation. As a result, concreteness effect could only be found in high frequency words.

The discrepancy between Zhang & Zhang (1997) and Chen & Peng (1998) studies could be due to the component character frequency effect and the definition of concreteness. Zhang & Zhang (1997) only controlled the whole word frequency while Chen & Peng (1998) controlled both whole word and component character frequency. Concreteness effect found by Zhang & Zhang (1997) in low frequency words might be caused by the use of low frequency concrete words, which contain high frequency component characters. However, Chen and Peng (1998) did not state clearly how to control the component character frequency. Despite of the control, they did not manipulate the component character frequency condition. As mentioned before, the second character that carries more semantic information will be affected by concreteness effect to a larger extent; thus, it is important to manipulate component character frequency to understand the relationship between concreteness effect and character frequency. Apart from the issue of character frequency, both studies did not define the rating scale clearly. Without a well-defined rating scale, the concreteness of each word might vary greatly among raters. Zhang & Zhang (1997) and Chen & Peng (1998) failed to have a consensus about the role of concreteness effect in Chinese language, thus, whether concreteness effect existed in Chinese word processing or not was still unknown.

Given the above considerations, the present study chose to manipulate both whole word and component character frequency across grades and provide an operationally-defined rating scale to determine the level of concreteness. Through these manipulations, it was hypothesized that if the dual coding theory was supported, concreteness effect

should exist despite of frequency effect; thus, concreteness effect would be expected in the processing of both high and low frequency words.

Another important issue to investigate is the development of frequency and concreteness effect. According to Chu (2000), significant word frequency effect was found in primary school-aged children in reading Chinese disyllabic words. A total number of 72 subjects with 24 subjects from each grade (Primary one, three and five) in a local primary school were recruited. The subjects were asked to read aloud 80 words that were designed according to their grade. The experiment manipulated the grade, whole word and component character frequency. Chu (2000) found that students read high frequency words better and low frequency words. Students read high frequency words better than low frequency words because they were more familiar to high frequency words. According to the Dual-Coding Theory (Paivio 1986), high frequency words consisted of more representational units in the verbal system than low frequency words while concrete words consisted of more representational units in imagery system than abstract words. It could be hypothesised that high frequency concrete words might consist of equally more representational units in both verbal and imagery system but low frequency concrete words consisted of less units in verbal system but more units in imagery system. As a result, the concreteness effect might be masked or become smaller for the high frequency words due to the equal amount of representational units in both systems. On the other hand, low frequency concrete words might be more easily activated because they consisted of more units in the imagery system than the verbal system, thus, stronger concreteness effect in low frequency words might be expected. Since the present study also manipulated component character frequency, words in low frequency in both the first and second character (LL) condition might show concreteness effect. As a result,

it is hypothesized that concreteness effect will be stronger in low frequency words and component characters than high frequency words.

Although both concreteness effect and frequency effect in reading performance has been studied before, the frequency factor and the concreteness factor were studied independently, and thus, interaction between the two factors is not clearly delineated. Even though Zhang & Zhang (1997) and Chen & Peng (1998) studied the interaction between concreteness and word frequency, their contradictory findings failed to give a clear picture on the relationship between word frequency and concreteness. To find out the interactions between concreteness and frequency, concreteness has to be defined operationally and component character frequency as well as the whole word frequency of the stimuli has to be controlled.

Chu (2000) found that primary one student relied on character-by-character reading strategy while primary three and five used word-by-word reading strategy. Therefore, the strategy used by subjects may affect the results. Taft (1994) also argued that when reading low frequency words, component character level would be activated but word level processing will be activated also when reading high frequency words. Precise control on whole word and component character frequency were needed for the investigation on the relationship among the three factors—whole word frequency, component character frequency and concreteness effect.

Another consideration in the present study was the developmental trend of concreteness effect on Chinese disyllabic words processing. Coltheart et al. (1988) found a significant interaction effect between reader group and imageability (concreteness) effect in English, in which, imageability effect only existed in poor readers. He argued that poor readers might rely on the semantic route in reading while competent readers could apply letter-to-sound rule in reading novel words. However, Coltheat et al. (1988)'s

work was done on populations using alphabetic languages, the present study will address the developmental trend of concreteness effect issue in Chinese language by primary school-aged children. Base on Coltheart et al. (1988)'s explanation, it is hypothesized that concreteness effect would be higher in low grade readers but lower in advance readers. Since students from higher grade would acquire better reading skill, they no longer rely on concreteness effect to process each word. As a result, concreteness effect might be less influential in higher graders but stronger in lower graders.

If the Dual-Coding Theory is correct, both high and low frequency concrete words will be read more accurately than abstract words. If there is concreteness effect in reading Chinese disyllabic words, the second character in Chinese disyllabic words that carries more semantic information will be affected by concreteness effect to a larger extent. If concreteness effect affects the reading processing of English words in the same way as Chinese disyllabic words, Coltheart et al. (1988)'s developmental hypothesis that concreteness effect would be higher in low grade readers but lower in advance reader will be confirmed in the present study. If concreteness, whole word and component character frequency effects play a role in children reading development, a significant interaction effect among them will be resulted in the present study. In order to answer the research questions, the concreteness level of each word was rated with an operationally-defined rating scale and whole word and component character frequency across grades were manipulated.

METHOD

Subjects

Subjects were recruited from students of a primary school in Hong Kong. P2 (P2), three (P3) and five (P5) were selected to participate in the present study. All students were born in Hong Kong and studied in local kindergarten.

In order to control for the intelligence factor and the reading performance, sixty students from each of the grades mentioned were screened by the Raven's Standard Progressive Matrices (Raven 1986) and the Chinese word reading subtest of The Hong Kong Test of Specific Learning Difficulties in Reading and Writing (Ho, Chan & Education Department, HKSAR Government, 2000).

Those students who scored within the 5^{th} and 95^{th} percentile in the Raven's test (Raven 1986) and within ±1.33 standard deviations in the Reading Test (Ho, Chan & Education Department, HKSAR Government, 2000) were eligible for the study. After the screening, thirty students from each grade were randomly selected from the eligible students. A total of 90 students participated in the study. The ages and performances in the intelligence and reading testes were shown in Table 1.

Table 1

The ages and performances in the intelligence test and reading test

Grade	Age		Raven's Progressive Matrices	Chinese word reading test
	Range	Mean	Mean standard score	Mean Standard Deviation
P2	7; 1-8;0	7; 6	109.17	0.4
P3	8;0-9;0	8;6	112.57	0.38
P5	10;1-11;3	10;7	115.5	0.5

Materials

Three sets of 800 nouns were selected from P2, P3 and P5 from the Hong Kong Corpus of Primary School Chinese (Leung & Lee 2002). All the nouns from the Corpus were come from primary school Chinese and General Studies Textbooks. In order to ensure that each noun was exposed to the student since Primary one (P1), both the whole

word frequency and component character frequencies were calculated cumulatively in each grade. For example, the cumulative whole word frequency of a word in P2 was the sum of the frequency of that word in P1 plus its frequency in P2; the cumulative component character frequency was the sum of the frequency of that character appeared in P1 plus its frequency in P2.

For the disyllabic words in each grade, they were divided into high and low whole word frequency. For high frequency words, 24%-25% of the words with highest frequencies from 5-2108 were taken from P3 and P5. Since students learnt fewer words in P2 when compared to P3 and P5, the cumulative frequencies appeared relatively low. The percentage of highest frequency words was adjusted to 36% with frequencies ranging from 3-335. For the low frequency words, words with frequency of one occupied 40%-45% in P2, P3 and P5. Therefore, 40%-45% of words with lowest frequency of one were taken from each grade to be the low frequency words.

For the component characters in each grade, they were also divided into high and low component character frequencies. For the high frequency characters, 35%-40% words with highest frequency, which was 170-4538 in primary three and 230-12829 in P5, were taken as the high character frequency in P3 and P5. For the low frequency characters, 33%-35% words with lowest frequency, which was 1-49 in P3 and 1-547 in P5, were taken as the low character frequency in P3 and P5. Similar to the situation in defining high frequency words for P2, there were not sufficient words in this grade, hence, it was necessary to expand the percentage of high and low character frequency. In P2, 53% words with highest frequency of 1552-2834 were taken as high frequency characters whereas 48% words with lowest frequency of 1-1378 were taken as low frequency characters.

After selecting three sets of 800 nouns based on their whole word and component character frequencies, all the nouns were rated on a seven-point rating scale to decide the level of concreteness. Ten undergraduates from the Department of Speech and Hearing Sciences were responsible for rating the words according to the seven-point rating scale (7=concrete, 1=abstract). Anchors with explanation were used to specify the concreteness rating (Appendix A). Ambiguous nouns that could neither be judged as abstract nor concrete and nouns that do not belong to any categories were rated as Neutral (Point 4) in the rating scale.

After the rating process, three sets of 160 nouns were selected from each grade. (Appendix C) To ensure that each noun was on the extreme level of concreteness and abstractness, abstract nouns must be rated on the point 1, 2 and 3 while concrete nouns must be rated on point 7 or 8. Since there were not enough number of nouns on point 1 and 2, nouns rated on point 3 (quite abstract) were also included in the stimuli from each grade. In addition, only those nouns with at least six raters' agreement on a common point would be taken in order to ensure that the rating of each noun was the majority agreement. These procedures could eliminate all outliers and ambiguous nouns, which might affect the concreteness level of each noun. Originally, it was planned to recruit subjects from P1 instead of P2. However, the corpus did not have sufficient words to be selected for rating and there were not enough students from P1, thus, P2 students were selected in the present study.

The stimuli were arranged in 16 conditions. There were two levels of whole word frequency—high and low. Under each frequency, the stimuli were subdivided into four levels according to their first and second component character frequency—high frequency in first and second characters (HH), high frequency in first character but low frequency in second character (HL), low frequency in first but high frequency in the

second character (LH) and low frequency in both the first and second character (LL). Under each component character frequency condition, the stimuli were further divided into abstract and concrete words. Examples of the stimuli were shown in Appendix B.

Each noun was printed on a plain white one-fourth of an A4 (210mm x 297mm) sized paper. Asian text font “xin xi ming ti (新細明體)” in font size 100 in black color was used for each noun.

Procedures

The data collection process was carried out in a classroom at the primary school participated in the present study. The subjects were asked to read aloud the 160 stimuli designed for their corresponding grade individually. Only one word was presented at each time. They were informed that there was not any time limitation in the whole reading task and the result would not be counted in their school academic results. The data collection process was audiotaped and marked online.

Measurement

Students’ performance was marked online on a scoring form. One mark was given for each correct production of the target word, whereas zero mark was given for each incorrect production or no response. The students’ performance was audiotaped to allow double-checking and phonetic transcriptions of the error productions.

Data analysis

The mean percentage in each condition of each subject was calculated. The mean scored was entered into a 3 x 2 x 4 x 2 four-way ANOVA with repeated measures. The students’ grades were the between group factor, which had three levels: P2, P3 and P5. The whole word frequency (Two levels: High and low frequency words), component character frequency (Four levels: HH, HL, LH and LL) and level of concreteness (Two

levels: concrete word and abstract word) were the within group factors. The mean scores of the students' performance was the dependent factor.

RESULTS

All the main and interaction (including two-, three- and four-way) effects were significant. In order to study the developmental trend of concreteness effect on reading across grades and the effect of word frequency and component character frequency on concreteness effect, the current study will focus on the following results:

Main Effect of Concreteness

Significant main effect of concreteness was found, $F(1, 87)=111.97$, $p<.001$, where concrete words were read more accurately than abstract words. This findings confirmed that concreteness effect exist in the reading process of Chinese disyllabic words.

Main Effect of Grade

Significant main effect was also found in grade, $F(2,87)=20.20$, $p< .001$. The differences between grades that contributed to the main effect were investigated with post hoc Tukey HSD test. It was found that P5 performed better than P3, and P2 whereas the difference between P3 and P2 was not significant.

Main Effect of Word and Component Character Frequency

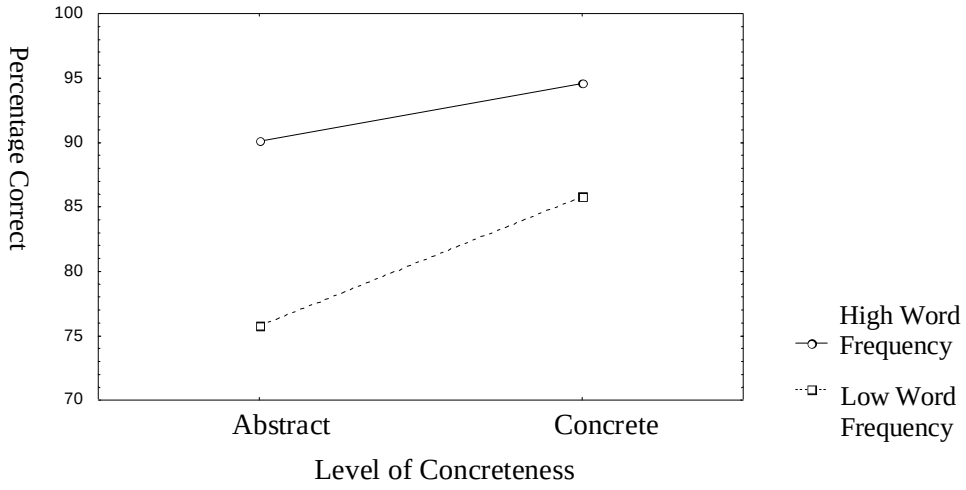

Figure 1. Interaction between word frequency and concreteness effect.

Significant main effect of word frequency was found, F (1,87)=345.720, p<. 001, where high frequency word were read more accurately than low frequency words. Significant main effect was also found in component character frequency, F (3,261)= 203.010, p<. 001. The main effect was further investigated with a Tukey HSD post hoc test. Pair-wise comparisons showed that students read HH word significantly better than HL, LH and LL while LL words was read significantly poorer than HH, HL and LH words No significant difference was found in HL and LH conditions.

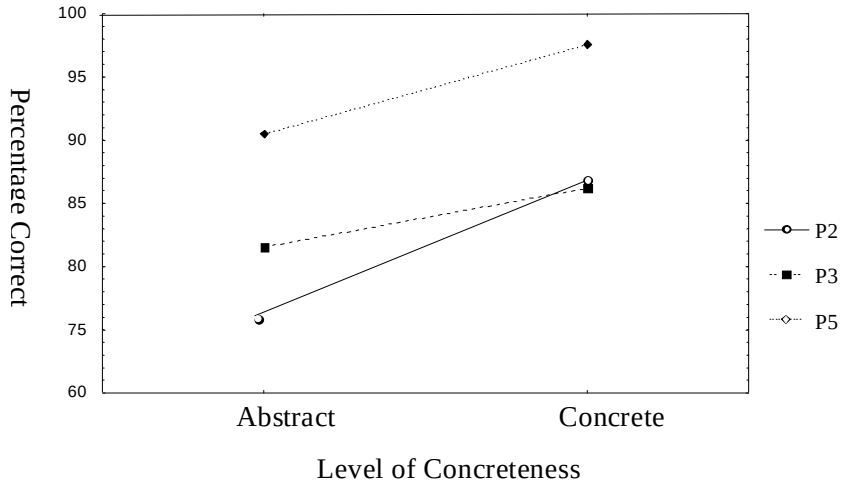

Figure 2. Interaction between grade and concreteness effect

Interaction between Word Frequency and Concreteness Effect

Significant interaction effect was found, $F(1,87)=40.36$, $p<.001$. (Figure 1) The Tukey HSD post hoc analysis showed significant concreteness effect in both high and low word frequency conditions, in which, the effect in low word frequency was larger than high word frequency, p<. 001.

Interaction between Grade and Concreteness Effect

Significant interaction effect was found, $F(2,87)=5.13$, $p<.01$. (Figure 2) The Tukey HSD post hoc analysis showed significant concreteness effect in all grades, p<. 010. This showed that concreteness effect existed in the reading process of P2, P3 and P5 students, in which, the effect in P2, $p<.001$ was slightly larger than P5, $p<.001$ and P5 was larger than P3, $p<.001$.

Four-way Interaction Effect

Four-way interaction among all factors was significant. The Tukey HSD post hoc test was carried out to investigate what contributed to the significant interaction effects. (Figure 3)

No significant concreteness effect was found in reading HH component character frequency in both high and low word frequency across grades. In contrast, significant concreteness effect was found in reading LL conditions in only low word frequency, p< .001 in all grades. Moreover, concreteness effect was not found in reading high frequency word by P3 and P5 students while it was found in reading low frequency words, p< .001 by all graders. To sum up, the results showed that the significant concreteness effect was mainly come from Low component character frequency and LOW word frequency conditions with no effect on all HH conditions.

To summarize, significant main effect of concreteness, grade, component character and word frequency were found. Significant two-way interaction between grade

and concreteness and between word frequency and concreteness were also found. Lastly, four-way interaction was significant which showed LOW word frequency and LOW component character frequency mainly contributed to the main concreteness effect.

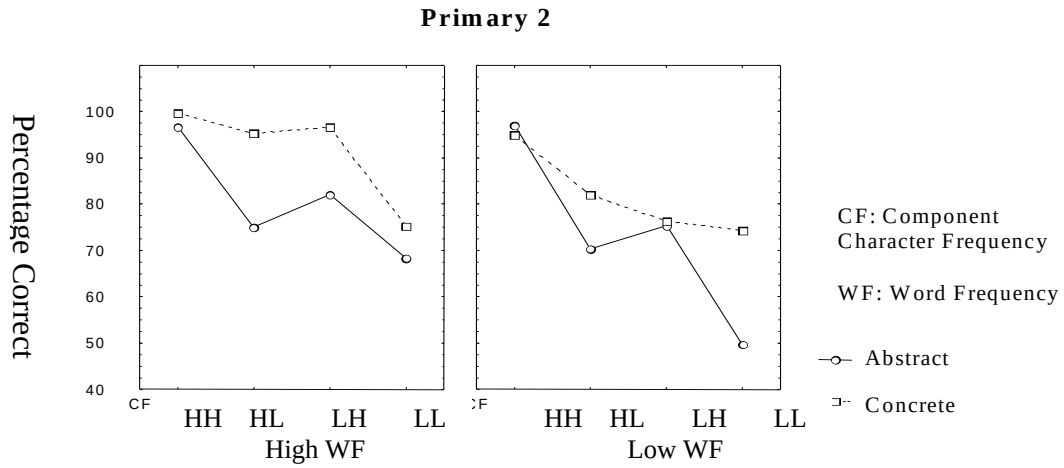

Figure 3a. Four-way interaction of P2.

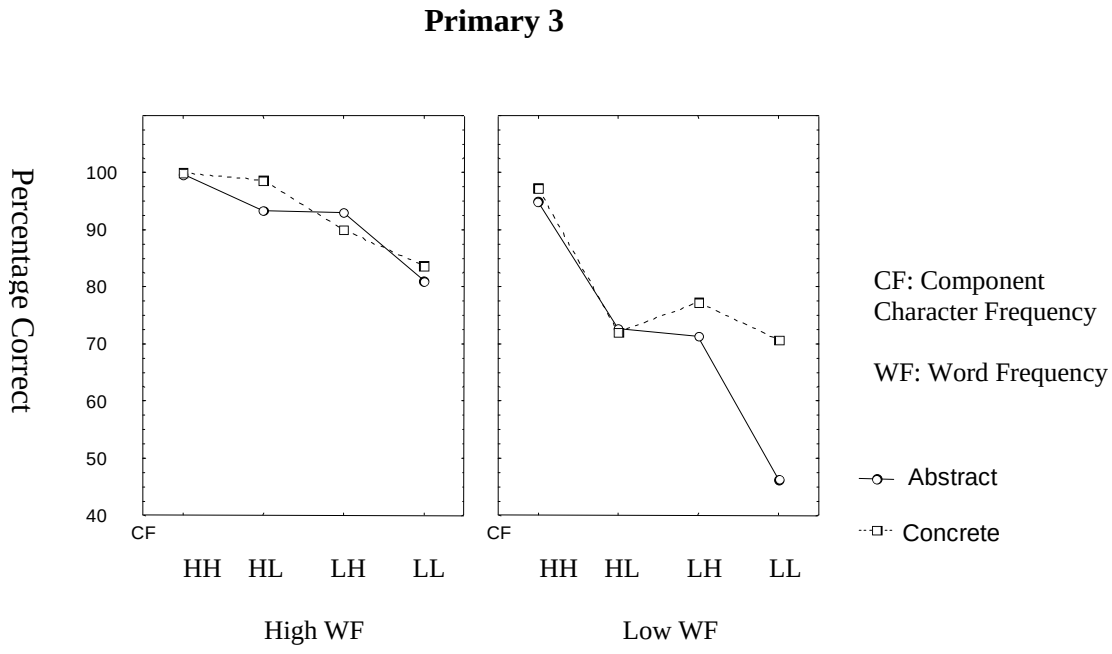

Figure 3b. Four-way interaction of P3.

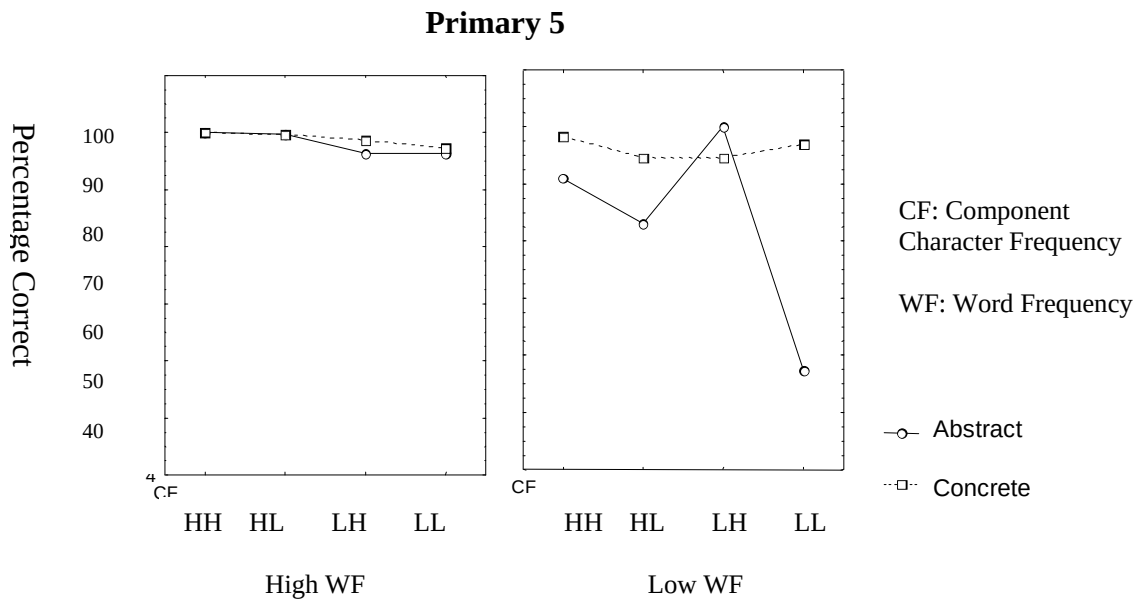

Figure 3c. Four-way interaction of P5.

DISCUSSION

Relationship among concreteness, whole word and component character frequency

The present study confirmed that concreteness effect exists in the reading process of Chinese disyllabic words by primary school-aged children. As mentioned in the introduction, the Dual Coding Theory (Paivio 1986) hypothesized that concrete words would be read better than abstract words because concrete words which contained representational units that could be processed by both verbal and imagery systems while abstract words could be processed by the verbal system only. Since concrete words received activation from the verbal and the imagery systems while abstract words only received activation from the verbal system, therefore, that concrete words could be activated more easily. With more representational units from both verbal and imagery systems in our memory system, concrete words across all frequencies will be memorized better than abstract words during the process of learning. Despite of word frequency, our memory of concrete words would be more stable than abstract words. When we were asked to read aloud concrete words, the representational units were activated in a faster and accurate way than those abstract words. The consolidated memory of concrete words

led to accurate reading performance. Thus, concrete words were read more accurate than abstract. The present study revealed significant main effect of concreteness effect in the reading process of Chinese disyllabic words by students from all grades that supported the Dual Coding Theory (Paivio 1986).

Significant interaction effect between concreteness and word frequency effect was found in both high and low frequency words. The Tukey HSD post hoc test revealed that concreteness effect in high frequency words was only found in P2 (Figure 3a) while concreteness effect in low frequency words was found in all grades (Figure 3). A possible explanation is that students were less familiar to the low frequency words, students had to rely on the verbal system only to process the low frequency words. Thus, concrete words were read better than abstract words. In high frequency words, students were more familiar to them and these words consisted of equally more representational units in the verbal systems. Hence, the activation of concrete words was faster and more accurate than abstract words since the representation units in imagery system were higher. The more activation, the more lexical information can be extracted from the words. Therefore, concreteness effect existed in both high and low frequency words.

The finding that concreteness effect existed in both high and low frequency words did not agree with Zhang & Zhang (1997) and Chen & Peng (1998)'s studies that concreteness effect was only found in low and high frequency words respectively. The reason was related to the interaction between grade and concreteness effect. Therefore, the reason responsible for the differences will be further discussed in the developmental trend issue.

The present study also found significant interaction effect between component character frequency and concreteness effect (Figure 3a, 3b and 3c), in which, HL and LL conditions mainly contributed to the effect while concreteness effect was not observed in

HH condition. The result showed that concreteness effect mainly existed in component character with low frequency. It was interpreted that students could gain direct access to the pronunciation of that character because the representational units in character with high frequency were sufficient to achieve the activation. However, there were not sufficient representational units in character with low frequency; thus, the students resorted to the semantic meaning of that component character. It meant that concrete character would be read more accurately than abstract character. Despite of the fact that the concreteness level of the stimuli was determined in the whole word level, most of the words in Chinese were modifier compound that carry more semantic information in the second character. Hence, the concreteness level of the second component character would reflect the concreteness level of the whole word to a certain extent. According to the result, the low frequency component character was the second character in both HL and LL conditions. The result confirmed with the hypothesis that the second character that carried more semantic information would be affected by concreteness effect to a larger extent.

To conclude, concreteness effect demonstrated in both high and low frequency words, in which, the effect was stronger in LOW frequency words and LOW frequency component character. This underlined that when the primary school aged children read unfamiliar concrete words could be read better than those unfamiliar abstract words.

Developmental Trend of Concreteness Effect

In the previous section, we found that concreteness effect in high frequency words was only found in P2 while concreteness effect in low frequency words was found in all grades. This implied that the extent of concreteness effect was different in students from different grades. This implication would lead to the discussion of the developmental trend of concreteness effect in reading in primary school-aged children.

The significant interaction effect between grade and concreteness effect demonstrated that concreteness effect was seen in P2, P3 and P5 students. Four-way interaction of all factors revealed only P2 students showed concreteness effect in reading high and low frequency words while P3 and P5 students showed the effect only in reading low frequency words. This demonstrated that concreteness effect affects lower grader (P2) in reading Chinese words more than the higher graders (P3 and P5). The result was similar to Coltheart et al. (1988)'s finding that imageability (concreteness) effect existed only in poorer readers when reading English words.

The reasons why concreteness effect was greater in lower grader (P2) than higher graders (P3 and P5) might be due to the frequency effect and better reading skill acquired by the higher graders (P5). In P2, concreteness effect was observed in both high and low frequency words. This demonstrated that P2 students relied on concreteness effect more than whole word frequency to process each pair of word. When the students promoted to a higher grade, concreteness effect dominated in low frequency words. It was interpreted that concreteness effect would be masked by high whole word frequency in higher graders. This told us that the higher grader the student was, the lesser the concreteness effect.

Significant main effect on grade demonstrated that P5 students' reading performance was significantly better than P2 and P3 students while P2 and P3's reading performance did not have significant difference. Since the present study has already controlled whole word and component character frequency, their improved reading performance could not be explained by increased exposures to different words. As seen from the result of P5, they almost got full marks in every condition of high frequency words. This was because their mature reading skills masked the concreteness effect in reading high frequency words. On the other hand, P2 and P3 did not have significant

different in their reading performance which implied that the concreteness effect could not be masked in P3. Therefore, it could only be explained that concreteness effect still existed in P3. In short, concreteness effect has already emerged since P2 but start to diminish in P5 because the effect was masked by mature reading skill of P5 students.

In the present study, concreteness effect was only found in reading low frequency words by P5 students due to their mature reading skills. In Zhang & Zhang (1997)'s study, their subjects were students from the Beijing University who should develop more mature reading skill than P5 students. Their mature reading skill masked concreteness effect in high frequency words. Thus, Zhang & Zhang (1997) only found concreteness effect in low frequency words. Similarly, Chen & Peng (1998) also recruited subjects from Beijing University; yet, the result was different. Chen & Peng (1998) found concreteness effect in high frequency word might be due to problems happened during the control of component character frequency, as they did not state out the method clearly. Hence, the difference in their results was due to the grade and component character frequency effects on concreteness effect.

Reading Strategies by Primary School-aged Students

Reading strategies in different grades were demonstrated by the results of significant four-way interaction of concreteness effect, grades, whole word and component character frequency. The Tukey HSD post hoc test showed that LOW frequency words and LOW frequency component character mainly contributed to the concreteness effect across grades. This result told us lower graders with less mature reading skills relied on concreteness effect when reading both high and low frequency words whereas higher graders with mature reading skills no longer depends on concreteness effect to read.

Another finding was the reading strategies of high and low frequency words. It was investigated by looking into the error pattern. (Table 2) For high frequency words, the errors production was assumed to be resulted from whole word level; for example, target word “安慰” which meant comfort was produced as “安排” which meant arrangement. Students generated another word with different semantic representation to replace the target word. For low frequency words, the error production was resulted from component character level; for example, “豪邁” which meant heroic style was produced as “豪萬” which was a nonword. Students tended to make phonological errors when they encountered a difficult word. These kinds of error were supported by Taft (1994)’s interactive-activation model. He proposed that representation of high frequency words was activated from word level because the activation was strong enough to activate the word level; whereas low frequency words was activated from character level because the activation was not strong enough to activate the word level, the activation had to move down to character level. The present study supported Taft (1994)’s model that primary school-aged student processed high frequency words from whole word level while low frequency words from component character level.

Activation of semantic representational units was also observed from the error patterns. In the error pattern of high frequency words, students tended to produce another meaningful words to substitute the target word. At this point, it was no doubt to question about whole word level processing for high frequency words. However, it was interesting to query about why the students would create a word that the meaning was totally unrelated to the target word. Another characteristic was student would depend on the meaning of the remaining character to produce the new word. For example, when students failed to produce the character “慰” in the word “安慰”, they would use the meaning of the character they knew—“安” to generate the new word “安排” which was

another meaningful word. This phenomenon could be explained by Zhou & Marslen-Wilson (2000)'s connectionist framework. (Figure 5)

Table 2

The percentage of different error types by P2, P3 and P5 students

	Error type	P2	P3	P5
High word frequency	Whole word level	**53%**	**53.7%**	**57.8%**
	Character level	13%	33.2%	23.2%
	No response	34%	13.1%	19%
	Total	100%	100%	100%
Low word frequency	Whole word level	21.5	23%	21.5%
	Character level	**49.5%**	**56%**	**62.4%**
	No response	29%	21%	16.1%
	Total	100%	100%	100%

S=Semantic units
P=Phonological units
O=Orthographic units

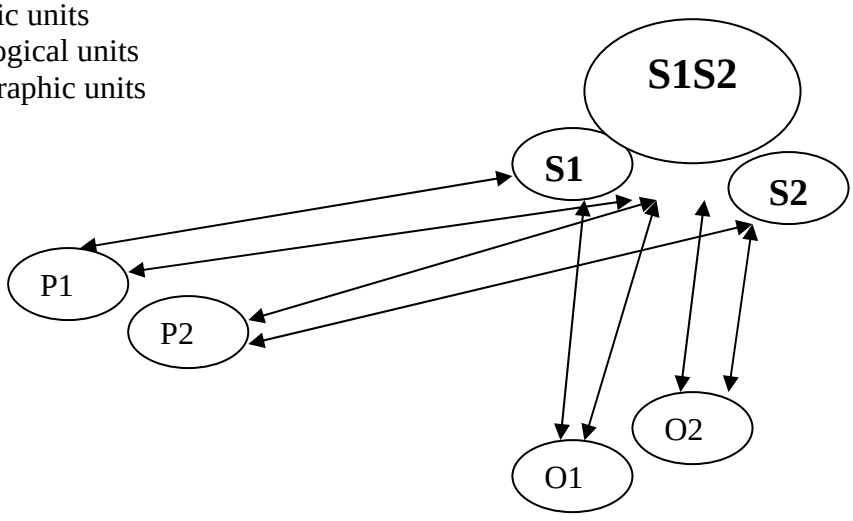

Figure 5. Zhou & Marslen-Wilson (2000)'s connectionist framework.

Unlike Taft (1994)'s interactive-activation model, Marslen-Wilson (2000)'s connectionist framework neither stressed on whole word nor component character level processing. Instead, it emphasized that lexical representation of compound words was interplay among semantic, orthographic and phonological activation. At the semantic level, Marslen-Wilson (2000) proposed that compound word shared common semantic representational units with the corresponding constituent (component character). Therefore, activation of semantic features of compound words would overlap with its constituents. Along with this logic, when a student failed to produce the character "慰" in the target word "安慰", the semantic units of the remaining character "安" could activate other character "排" that shared common features of the target word. After that, the semantic activation of the newly generated compound word "安排" feedback to the orthographic and phonological units. As a result, the student produced a word with totally different meaning "安排". This indicated that semantic processing of whole word and component character level appeared in the lexical processing of Chinese words. When encountering a difficult word, student would depend on the semantic meaning of the character to generate a new meaningful word.

To conclude, the present study demonstrated concreteness effect in the reading process by primary school-aged student in Hong Kong. It solved the dilemma of previous studies on concreteness effect by showing significant concreteness effect on both high and low frequency words. Through manipulating the whole word and component character frequency across grades, concreteness effect has been emerged since P2 but easily masked by the word frequency effect when the students mastered a better reading skill. Moreover, the concreteness level of a compound word and semantic meaning of the compound word and its constituent were used as the reading strategies by the students.

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Appendix B

Table 1

Examples of all conditions of stimuli in each grade

WF	HIGH								LOW							
CF	HH		HL		LH		LL		HH		HL		LH		LL	
A/C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C
P2	生活	毛衣	來源	香蕉	難過	糕點	驕傲	銀行	明年	經書	想法	魚竿	隨和	淚水	攝氏	荔枝
P3	過去	白鵝	可惜	風箏	主動	蘋果	拼命	警察	用意	寶弓	風波	果汁	志氣	橡樹	孤寂	孕婦
P5	才能	同學	愛好	小麥	壓力	舌頭	勉強	麻雀	起因	教師	受辱	氣泵	無畏	寵物	豪邁	肝臟

Note. WF= word frequency; CF=character frequency; A/C= Abstractness/ Concreteness; P2= primary two; P3= primary three; P5= Primary 5

The use of concreteness as a reading strategy by the primary students underlined semantic processing of Chinese compound words. In the present study, the level of concreteness of each compound word was determined by the semantic meaning from whole word. So, the lexical representation units were at the semantic level. Results showed that concreteness effect existed in students from P2, P3 and P5; thus, this implied that students used semantic processing as a reading strategy as early as P2.

The presence of semantic processing in primary school-aged students agreed with Taft (1994)'s interactive-activation model in morphological processing (Figure 4). In his model, there are orthographic and phonological units. Each unit consists of activation units such as radical level, character level, word level and lastly, concept level. He proposed activation of each morpheme enters into the model starting from the smallest unit, which can be moved up or down the activation units. The concept units in the model mean "the interface between the representation of form and meaning" (Taft 1994). So, the compound words would access the concept unit after passed up the lower level activation unit. Since the level of concreteness was determined by the semantic meaning of the whole compound word, the presence of concreteness effect proved that semantic processing existed in the reading process of Chinese compound words.

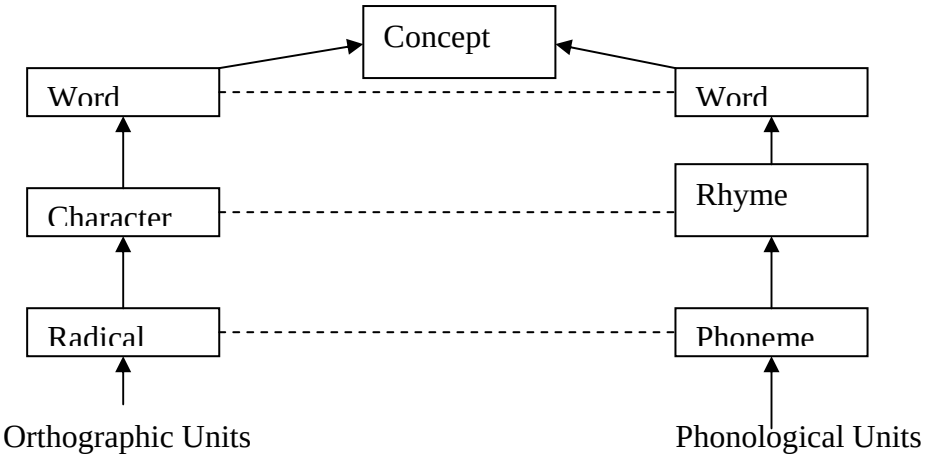

Figure 4. Taft (1994)'s interactive-activation model in morphological processing.

Appendix A

Table 1

Definition of the seven-point rating scale

Point	Level of Concreteness	Operational Definition	Example
1	*Extremely Abstract*	Something that cannot be touched, seen or smelt	概念/ 意思 (Concept/ meaning)
2	*Very Abstract*	Something that cannot be touched, seen and smelt but it can be realized through our feeling or thoughts	羨慕/ 驚奇 (adore/ surprise)
3	*Quite Abstract*	Nouns that indicates directions, timing and locations	西面/早上 (The West/ morning)
4	*Neutral*	Nouns that neither concrete nor abstract and nouns that between abstract and concrete	數學/對白 (mathematics/ dialogue)
5	*Quite Concrete*	Objects or collective terms of things that can be seen, smelt, touched or felt through manipulation	北風/雪花 (The north wind/ snowflakes)
6	*Very Concrete*	Collective terms of things that can be seen, touched or smelt	飲料/動物 (Drinks/ animals)
7	*Extremely Concrete*	Objects that can be touched, seen or smelt directly	杯子/西瓜 (Cup/ watermelon)

Appendix C

Table 1

Stimuli for Primary 2

水喉	左右	自愛	安慰	東面
蟬兒	接納	白人	汗水	茶點
翡翠	放心	時候	罐頭	盆栽
盲人	複雜	蛋糕	刀叉	意
遲到	酒壺	歉意	空格	讀物
坦白	頭髮	園丁	甘心	孕婦
生活	想念	風波	花瓣	貨品
需要	昨天	服飾	葡萄	便服
來源	本領	簡要	心聲	經書
悲痛	意義	疲累	饅頭	玻璃
地毯	毛衣	香蕉	鼓勵	飾物
墓地	抱怨	中學	愉快	零食
山	清明	白鵝	朋友	皇帝
發怒	光榮	習慣	動物	好書
討論	風衣	晚上	電話	用意
不祥	魚竿	過程	自大	銀行
靈活	糕點	困擾	果汁	以後
磁鐵	開懷	球體	專心	橡樹
難過	眼睛	蘋果	身體	孤寂
距離	水果	山頭	援手	贊成
歡樂	西瓜	努力	羞愧	烏鴉
雙手	老鷹	效果	運動	字典
蝴蝶	車長	後邊	興奮	現象
秩序	呆	燕兒	偷快	寶弓
糊塗	功課	志氣	驕傲	驚人
技能	途徑	海藻	菠蘿	歡欣
圍巾	太陽	鞋子	宰相	淚水
方式	快樂	花樣	盒子	樓宇
現在	明白	獎券	驚慌	菊花
堅決	心腸	可笑	蓮花	雨傘
煩惱	了解	咖啡	公園	欣慰
忙亂	科學	風箏	功效	廢物

Table 2

Stimuli for Primary 3

手柄	危險	成果	安慰	心聲
雙手	滿足	老人	石頭	菊花
輪船	明天	晚上	兔子	蜘蛛
兄弟	印象	喇叭	卡通	成就
整天	蝌蚪	近來	果汁	種子
灰心	衣裳	頭部	神氣	菠菜
生活	禮貌	開朗	風筒	孩子
過去	低聲	魚竿	麻雀	生物
清晨	可惜	甜美	功能	車長
驚慌	選擇	寂寞	男兒	玫瑰
水塘	水果	郵票	勝利	熟食
爐具	攝氏	工具	傷心	松樹
生菜	自大	頭髮	朋友	蜻蜓
親切	起勁	過程	玩具	經書
形態	家課	現在	水缸	明年
心思	書架	急	今早	警察
敬愛	獵人	貢獻	車廂	快樂
楊柳	歡暢	衣	愉快	淚水
主動	工蜂	肉類	老師	速度
耐性	功課	雨衣	陌生	贊成
功用	白鵝	任意	悲痛	蝸牛
蘋果	風箏	行動	食物	雨傘
葡萄	食水	寫意	慚愧	習慣
困難	北方	雪人	底下	荔枝
傷害	同學	幼年	影響	隨和
需要	拚命	飛機	蟑螂	想法
豆角	毛衣	骨頭	熨斗	穀類
方式	同意	前頭	廠長	蠟燭
開心	時候	鋼琴	希望	桃花
深刻	光陰	美好	芒果	電話
思念	了解	芥蘭	太陽	苦惱
發怒	隨意	香蕉	空間	醫生

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Table 3

Stimuli for Primary 5

生羊	好奇	語氣	放棄	快活
桃花	無畏	學弟	零食	劉海
肝臟	服氣	開心	舌頭	麻雀
屍體	憧憬	螞蟻	刀槍	法子
榜樣	寺廟	晦氣	時針	物料
針對	工廠	氣泵	甘心	爪印
才能	想念	受辱	動脈	學生
滿意	脾氣	水煲	鋼琴	十字
後悔	自私	肆意	來年	經書
豪邁	習慣	惶恐	寵物	玫瑰
月曆	市民	水池	羨慕	裙子
橡樹	惦掛	市花	壓力	佛像
工蜂	真心	天橋	動物	芥蘭
發悶	安逸	情況	國家	教師
基礎	海報	愛國	山羊	起因
內咎	電鈕	愛好	自大	番茄
穩定	松樹	羞怯	食肆	吃力
松鼠	意念	車長	弱能	頸部
灰心	小麥	卡通	身體	侮辱
惡劣	同學	山頭	惱人	焦急
對面	心臟	值得	瘋狂	喇叭
蟬兒	電話	偷快	頭部	手錶
狐狸	眼球	意向	憤怒	起勁
勉強	衝動	穀類	堅定	檸檬
慚愧	老師	茫然	糊塗	豪放
愉快	寂寞	國旗	朱砂	高昂
弓箭	公物	蘋果	甘薯	廁所
安慰	生活	不服	補品	烏龜
道理	時候	咖啡	挫折	乳類
猶豫	可悲	動機	饅頭	頭髮
仰慕	友誼	翡翠	人類	悽慘
迷	末年	月餅	多疑	桔子